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# **M**ODERN ENGINEERING AND INNOVATIVE TECHNOLOGIES

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## About the journal

The International Scientific Periodical Journal "Modern Technology and Innovative Technologies" has been published since 2017 and has gained considerable recognition among domestic and foreign researchers and scholars.

Periodicity of publication: Quarterly

The journal activity is driven by the following objectives:

- Broadcasting young researchers and scholars outcomes to wide scientific audience
- Fostering knowledge exchange in scientific community
- Promotion of the unification in scientific approach
- Creation of basis for innovation and new scientific approaches as well as discoveries in unknown domains

The journal purposefully acquaints the reader with the original research of authors in various fields of science, the best examples of scientific journalism.

Publications of the journal are intended for a wide readership - all those who love science. The materials published in the journal reflect current problems and affect the interests of the entire public.

Each article in the journal includes general information in English. The journal is registered in INDEXCOPERNICUS.

### Sections of the Journal:

Library of Congress Classification Outline	Sections
Subclass TJ / TJI-1570	Mechanical engineering and machinery
Subclass TK / TK1-9971	Electrical engineering.
Subclass TA / TA165	Engineering instruments, meters, etc. Industrial instrumentation
Subclass TK / TK5101-6720	Telecommunication
Subclass TK / TK1-9971	Electrical engineering. Electronics. Nuclear engineering
Subclass TN / TN1-997	Mining engineering. Metallurgy
Subclass TS / TS1950-1982, TS2120-2159	Animal products., Cereals and grain. Milling industry
Subclass TS / TS1300-1865	Textile industries
Subclass TK / TK7800-8360	Electronics
Subclass T / T55.4-60.8	Industrial engineering. Management engineering
Subclass T / T351-385	Mechanical drawing. Engineering graphics
Subclass TA / TA1001-1280, Subclass TL / TL1-484, Subclass TE / TE1-450, Subclass TF / TF1-1620	Transportation engineering, Motor vehicles. Cycles, Highway engineering. Roads and pavements, Railroad engineering and operation
Subclass TH / TH1-9745	Building construction
Subclass T / T55-55.3	Industrial safety. Industrial accident prevention
Additional sections	<i>Innovative economics and management, Innovations in pedagogy, Innovative approaches in jurisprudence, Innovative philosophical views</i>

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Articles should correspond to the thematic profile of the journal, meet international standards of scientific publications and be formalized in accordance with established rules. They should also be a presentation of the results of the original author's scientific research, be inscribed in the context of domestic and foreign research on this topic, reflect the author's ability to freely navigate in the existing bibliographic context on the problems involved and adequately apply the generally accepted methodology of setting and solving scientific problems.

All texts should be written in literary language, edited and conform to the scientific style of speech. Incorrect selection and unreliability of the facts, quotations, statistical and sociological data, names of own, geographical names and other information cited by the authors can cause the rejection of the submitted material (including at the registration stage).

All tables and figures in the article should be numbered, have headings and links in the text. If the data is borrowed from another source, a bibliographic reference should be given to it in the form of a note.

The title of the article, the full names of authors, educational institutions (except the main text language) should be presented in English.

Articles should be accompanied by an annotation and key words in the language of the main text and must be in English. The abstract should be made in the form of a short text that reveals the purpose and objectives of the work, its structure and main findings. The abstract is an independent analytical text and should give an adequate idea of the research conducted without the need to refer to the article. Abstract in English (Abstract) should be written in a competent academic language.

The presence of UDC, BBK

Acceptance of the material for consideration is not a guarantee of its publication. Registered articles are reviewed by the editorial staff and, when formally and in substance, the requirements of the journal are sent to peer review, including through an open discussion using the web resource [www.sworld.education](http://www.sworld.education)

Only previously unpublished materials can be posted in the journal.

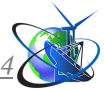
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The editors of the journal are aware of the fact that in the academic community there are quite widespread cases of violation of the ethics of the publication of scientific research. As the most notable and egregious, one can single out plagiarism, the posting of previously published materials, the misappropriation of the results of foreign scientific research, and falsification of data. We oppose such practices.

The editors are convinced that violations of copyrights and moral norms are not only ethically unacceptable, but also serve as a barrier to the development of scientific knowledge. Therefore, we believe that the fight against these phenomena should become the goal and the result of joint efforts of our authors, editors, reviewers, readers and the entire academic community. We encourage all stakeholders to cooperate and participate in the exchange of information in order to combat the violation of the ethics of publication of scientific research.

For its part, the editors are ready to make every effort to identify and suppress such unacceptable practices. We promise to take appropriate measures, as well as pay close attention to any information provided to us, which will indicate unethical behavior of one or another author.

Detection of ethical violations entails refusal to publish. If it is revealed that the article contains outright slander, violates the law or copyright rules, the editorial board considers itself obliged to remove it from the web resource and from the citation bases. Such extreme measures can be applied only with maximum openness and publicity.



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## MODELING OF IDENTIFICATION OF THE STAGE OF THE LIFE CYCLE OF THE ENTERPRISE BY METHODS OF FUZZY LOGIC

### МОДЕЛЮВАННЯ ІДЕНТИФІКАЦІЇ СТАДІЇ ЖИТТЄВОГО ЦИКЛУ ПІДПРИЄМСТВА МЕТОДАМИ НЕЧІТКОЇ ЛОГІКИ

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**Abstract.** The article proposes an economic-mathematical model for determining the indicator of the life cycle of the enterprise on a set of quantitative indicators. To implement the life cycle indicator model, it is proposed to use fuzzy set theory, in particular, the Mamdani fuzzy inference algorithm, which involves constructing triangular membership functions for the output, and  $z$  and  $s$ -type membership functions for the inputs.

The base of fuzzy rules which allows to receive accurate value of indicator of an indicator of a life cycle of the enterprise is constructed. The paper presents indicators and their interval values, with which it is proposed to determine the stage of the life cycle of the enterprise.

**Keywords:** enterprise life cycle, fuzzy logic, membership function, modeling, linguistic variable, term set.

**Introduction.** An entity, regardless of ownership, industry and scale of activity, obeys the cyclical laws of life and naturally does not avoid crises.

Determining the stage of the life cycle of the enterprise will allow to prepare for the emergence of certain crisis phenomena, to prevent their possible occurrence and deepening.

Depending on the stage of the business entity, the strategic decision-making process takes place. This process involves the development of targeted actions to achieve the maximum effect of the enterprise, in particular, in the event of a crisis, the company's goal will be to minimize staff costs, rational use of resources, restraining the decline in sales.

However, to solve this problem it is necessary to determine the stage of the life cycle of the enterprise at a particular time.

**Analysis of recent research and publications.** Many specialists dealt with the life cycle of the enterprise and the peculiarities of the functioning of the enterprise at one or another stage, namely: I. Adizes [1], G.O. Kozachenko [2], L. Griner [3], B.Z. Milner [5], S.V. Koryagina [6], L. Ligonenko [10], V. Vasylenko [15] and others.

**The purpose of the scientific article** is to develop an economic-mathematical model for identifying the stage of the life cycle of the enterprise using the methods of fuzzy logic.

**Research results.** Today, in the economic literature there is a significant number of views on the definition of "enterprise life cycle".

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Thus, G.O. Kozachenko [2] interprets the concept of “life cycle” as a set of stages of the system, successively changing each other, and each of which is characterized by a specific purpose and state of both the large production and financial system as a whole and its structural units, special a form of organizational mechanism that implements the achievement of strategic and operational goals of the system.

In his work L. Griner [3] considers the concept of “life cycle of the enterprise” as a set of five phases of development (evolution), which end in a revolutionary crisis.

I. Blank [4] defines the life cycle of the enterprise as a general period of time, from the beginning of the enterprise to the natural cessation of its existence or revival on a new basis.

B.Z. Milner [5] considers that the life cycle is a predictable change with a certain sequence of states over time.

S.V. Koryagina [6] does not identify the concept of enterprise life cycle with the concept of total life expectancy of the enterprise, but considers the life cycle of the enterprise as a set of stages that create a complete cycle of development over a period of time.

N. Rodionova in work [7] considers the life cycle of the enterprise as certain patterns in the development of any enterprise, which may differ in speed and amplitude of the level of development.

As we can see, there is no single, unified interpretation of the concept of “life cycle of the enterprise”, so we believe that the life cycle of the enterprise - is a period of enterprise life, which consists of certain stages at each of which the company develops within the relevant management decisions, from the conjuncture of the external and internal state of the system.

The period of existence of the enterprise is inevitably accompanied by the process of changing from one stage to another stage of operation of the entity.

In various works, researchers identify from four to ten stages of the life cycle of the organization [8].

The theory of the life cycle of organizations developed by the I. Adizes [1] has gained considerable popularity among researchers. The I. Adizes’s model includes ten stages of the life cycle of the organization: nursing, “baby stage”, rapid growth stage, youth, prosperity, stability, aristocracy, early bureaucratization, bureaucratization and death.

I. Blank [4] considers the development of the enterprise at the stages of birth, childhood, adolescence, early maturity, ultimate maturity and aging.

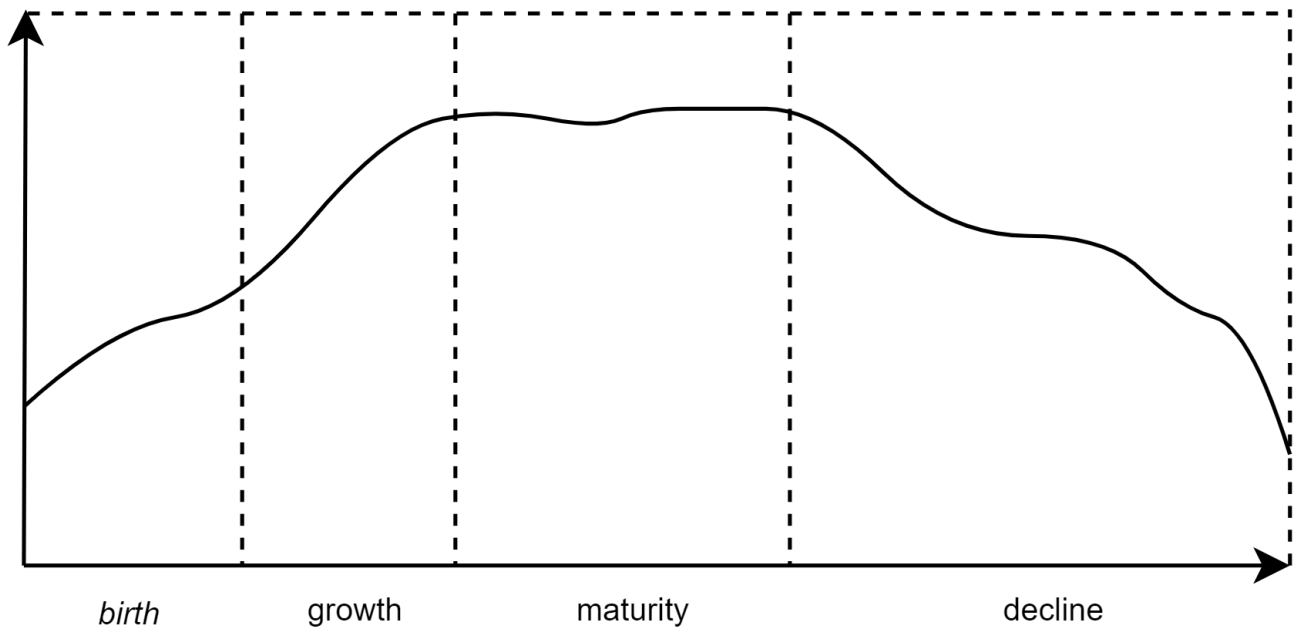
J. Lippit [9] identifies three stages of the life cycle of the enterprise: the stage of birth, the stage of youth, the stage of maturity.

L. Ligonenko [10] identifies four stages of the life cycle of the enterprise, among which: the stage of rise, the stage of inhibition of development, the stage of crisis, the stage of recovery.

Due to the strong differentiation of the stages of the life cycle, we propose to distinguish four stages of the life cycle of the enterprise: “Birth”, “Growth”, “Maturity”, “Decline”.



On Fig. 1 schematically shows the transition from one stage of enterprise development to another.



**Fig. 1. Stages of the life cycle of the enterprise**

Source: generalized by the author on the basis of processed sources [1,2,7]

The problem of determining the stage of the life cycle of the enterprise is that currently there is no single method of calculating the life cycle of the enterprise. The vast majority of existing models of the life cycle of the enterprise are empirical in nature and do not have a mathematical apparatus of analysis in the economic plane.

The problems of determining the stage of the life cycle of the enterprise can also include the direct difficulty of determining the limits of both input values and the limits of a certain output indicator, which would characterize the stage of the life cycle of the enterprise. In addition, there is the problem of choosing the optimal number of indicators that would fully assess each stage of the life cycle of the enterprise. This is explained by the fact that the presence of a small array of input data may not fully characterize the affiliation of the enterprise to one of the stages of the life cycle, and redundant - to overload the mathematical apparatus of calculation, which will slow down the calculation process and reduce accuracy.

Given the above, we propose to determine the indicator of the stage of the life cycle of the enterprise using the theory of fuzzy sets.

To determine the stage of the life cycle of the enterprise, we propose an algorithm that is graphically represented on Fig. 2.

To determine the level of the enterprise’s attitude to one of the stages of the life cycle, we declare a linguistic variable  $s = \langle\langle \text{LCE stage} \rangle\rangle$ . For a variable  $s$ , the universal set is the segment  $[0;1]$ , the set of values of the variable  $s$  is term-set

$S = \{S_1, S_2, S_3, S_4\}$ , where

$S_1 = \langle\langle \text{Decline} \rangle\rangle;$

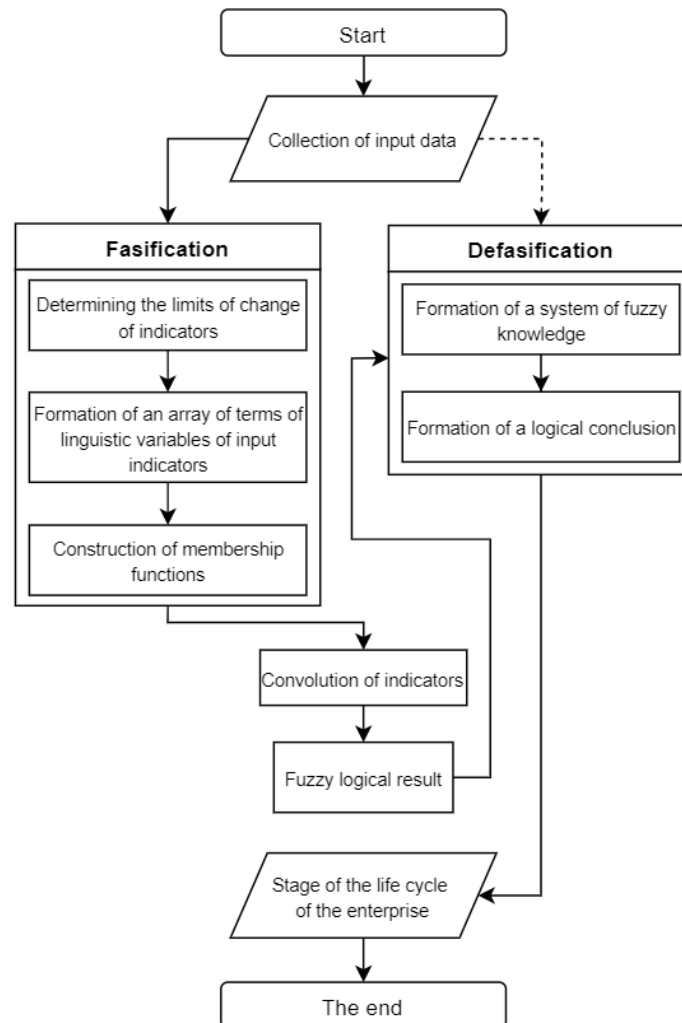




$S_2 = \text{«Birth»};$

$S_3 = \text{«Growth»};$

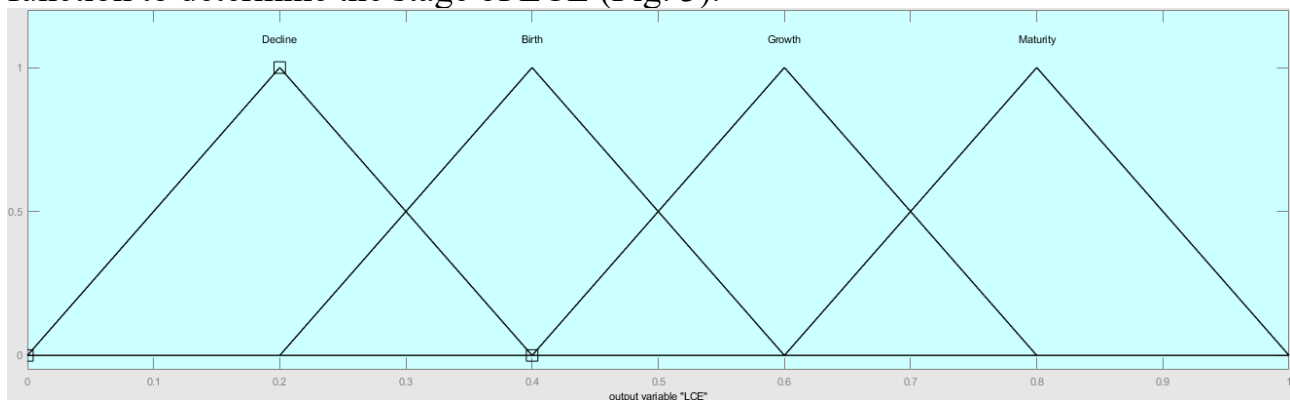
$S_4 = \text{«Maturity»};$



**Fig. 2. Algorithm for determining the stage of the life cycle of the enterprise**

Source: developed by the author

Using the “Fuzzy Logic Designer” tool of the MATLAB software package according to the Mamdani fuzzy derivation algorithm, we construct a membership function to determine the stage of LCE (Fig. 3).



**Fig. 3. Membership function to determine the stage of LCE**

Source: developed by the author



The triangular membership function to a fuzzy term is analytically defined as follows:

$$\mu(x) = \begin{cases} 0, & x < a \\ \frac{x-a}{b-a}, & a \leq x < b \\ \frac{c-x}{c-b}, & b \leq x \leq c \\ 0, & x > c \end{cases} \quad (1)$$

where  $a, b, c$  - are some numerical parameters that characterize the boundaries of the linguistic term, ordered by the relation  $a \leq b \leq c$ .

Based on the above, the linguistic variable “LCE stage” will belong to one of the four term sets (Table 1).

**Table 1**

**The range of values of terms for modeling a four-level classifier**

Linguistic variable	LCE stage			
	Decline	Birth	Growth	Maturity
The range of values of the term carrier	[0; 0,2; 0,4]	[0,2; 0,4; 0,6]	[0,4; 0,6; 0,8]	[0,6; 0,8; 1]

Source: compiled by the author

The stage of the life cycle of the enterprise is assessed by analyzing the indicators that characterize the effectiveness of the enterprise  $\{x_i\}, i = \overline{1, N}$ . In Table 2 we offer a list of indicators and their intervals by which it is possible to determine the life cycle of the enterprise.

**Table 2**

**An array of indicators to determine the stage of LCP**

Variable	Indicator	Determination of the indicator on stages of LCP			
		Birth	Growth	Maturity	Decline
$x_1$	Changing of net financial result	[0; 1]	[1; +∞)	[1; +∞)	[−∞; 1]
$x_2$	Changing of net gross result	[0; 1]	[0; 1]	[1; +∞)	[−∞; 1]
$x_3$	Changing of capital	[0; 1]	[1; +∞)	[1; +∞)	[−∞; 1]
$x_4$	Changing of costs	[1; +∞)	[1; +∞)	[−∞; 1]	[1; +∞)
$x_5$	Changing of productivity	[0; 1]	[1; +∞)	[1; +∞)	[−∞; 1]
$x_6$	Changing of the payroll	[0; 1]	[1; +∞)	[1; +∞)	[−∞; 1]
$x_7$	Changing of production	[0; 1]	[1; +∞)	[0; 1]	[−∞; 1]
$x_8$	Changing of depreciation of fixed assets	[0; 1]	[1; +∞)	[0; 1]	[−∞; 1]
$x_9$	Changing of employment of production facilities	[0; 1]	[1; +∞)	[0; 1]	[−∞; 1]

Source: compiled by the author

Indicators  $x_1$  and  $x_2$  will be considered as a set-carrier of the linguistic variable  $H_i$ , that contains the terms:



$H_1 = \langle\langle l\_l \rangle\rangle$  (low level);

$H_2 = \langle\langle a\_l \rangle\rangle$  (average level);

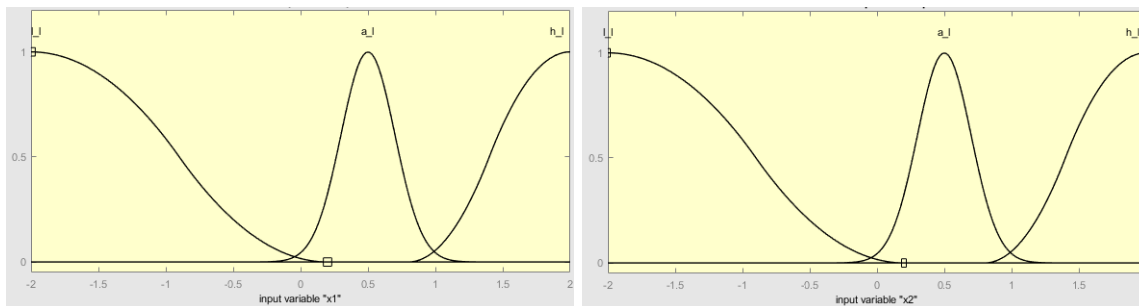
$H_3 = \langle\langle h\_l \rangle\rangle$  (high level).

Indicators  $x_3 - x_9$  will be considered as a set-carrier of the linguistic variable  $H_i$ , that contains the terms:

$H_1 = \langle\langle l\_l \rangle\rangle$  (low level);

$H_3 = \langle\langle h\_l \rangle\rangle$  (high level).

Low values of indicators  $x_1$  and  $x_2$  will be characterized  $z$  - type membership function; the average level will correspond to the Gaussian membership function, and high level –  $s$  - type membership function (Fig. 4).



**Fig. 4. Membership function for indicators  $x_1$  and  $x_2$**

Source: developed by the author

As for indicators  $x_1, x_2$ , and for indicators  $x_3 - x_9$ , proposed to apply  $z$  - type membership function for low values of indicators, and  $s$  - type membership function for high values of indicators (Fig. 5).

After forming the membership functions of the evaluation indicators, we define a fuzzy knowledge base about the relationship of inputs and outputs of the model for determining the stage of LCP through a set of fuzzy rules (Fig. 6).

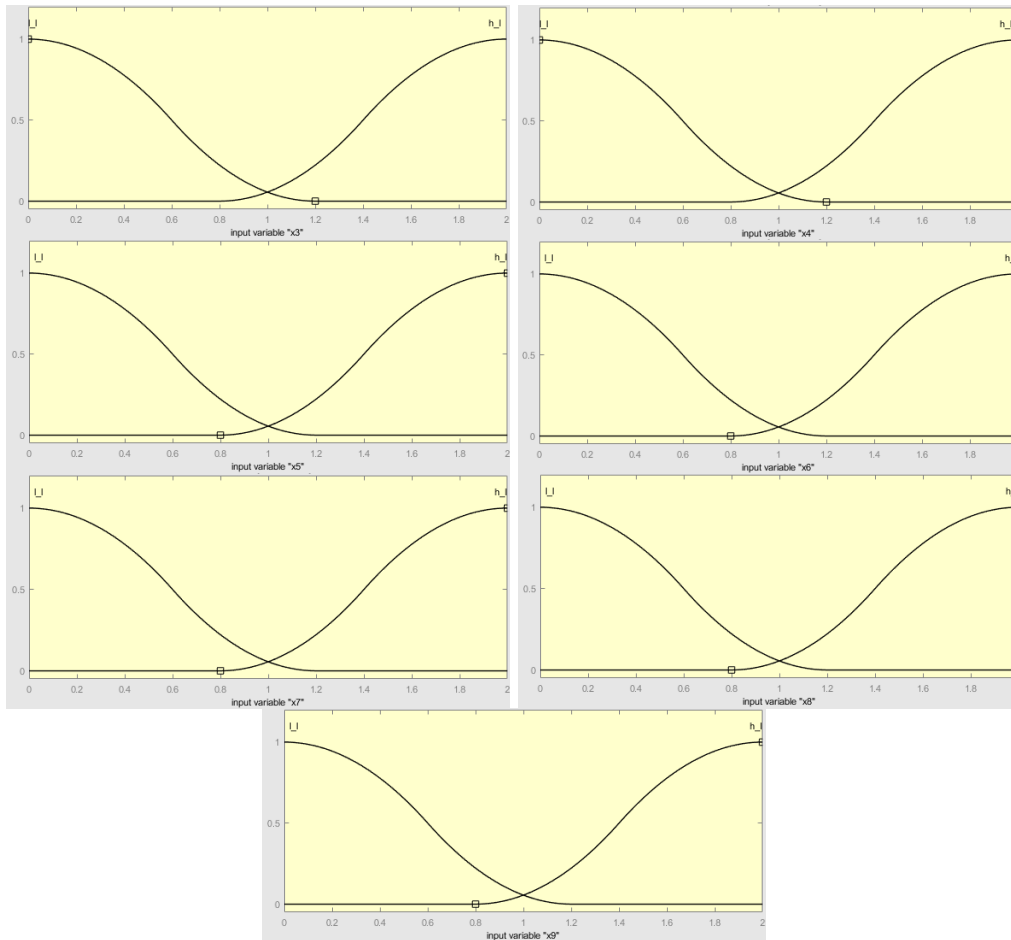
As a result of processing of input indicators and carrying out operations on fuzzy sets we receive the indicator which characterizes a stage of a life cycle of the enterprise expressed by accurate number. The “Fuzzy Logic Designer” tool allows the researcher to simulate situations in conditions of uncertainty. Based on the obtained indicator of the stage of the life cycle, the company makes a certain strategic decision.

**Conclusions.**

Fuzzy systems should be used when there is no accurate mathematical model of the system. Fuzzy set theory makes it possible to use inaccurate and subjective knowledge about a subject area without formalizing them in the form of traditional mathematical models.

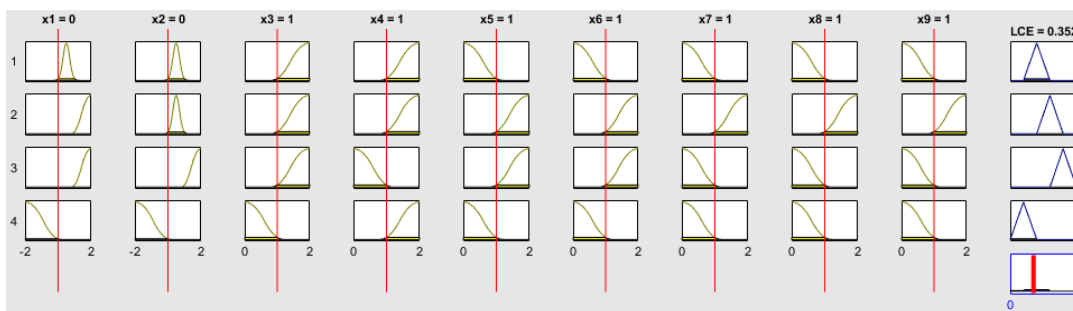
Thus, the use of the developed economic-mathematical model will allow to identify the stage of the life cycle of the enterprise. Determining the stage of the

development cycle at which the company is now, will ensure its stable and efficient operation.



**Fig. 5. Membership function for indicators  $x_3 - x_9$**

Source: developed by the author

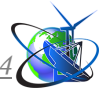


**Fig. 6. Matrix of fuzzy inference rules**

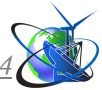
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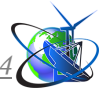


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